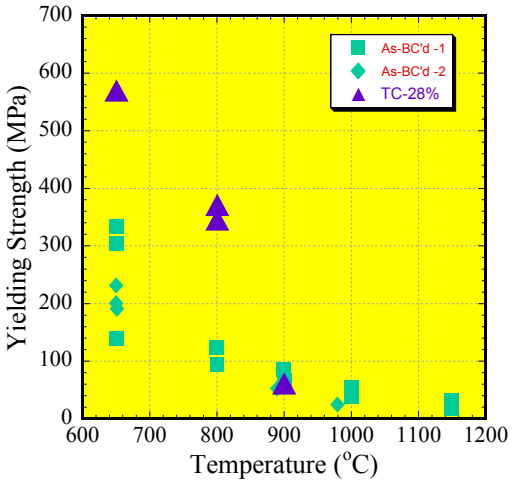
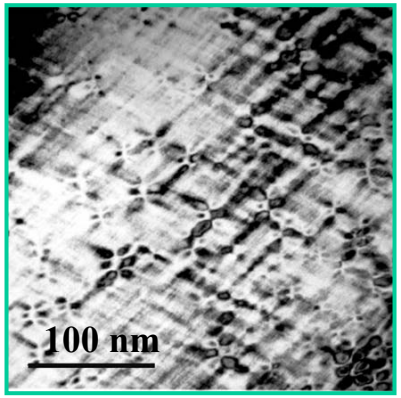
"Use of Microsample Testing to Characterize and Model Bond Coat Performance and TBC Life"

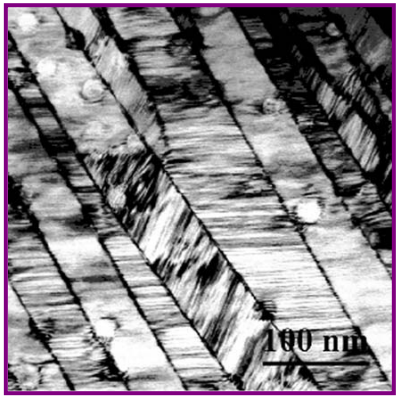
K.J. Hemker, Johns Hopkins University, Grant No. DMR9986752

- Thermal barrier coatings offer the greatest potential for increasing the performance of gas turbine engines.
- Microsample preparation and testing have allowed us to measure bond coat properties (CTE, E, σ_y, $\Delta\sigma_{relax}$), and to show that they change dramatically as a result of thermal exposure.
- Post mortem and in situ TEM and X-ray analyses have uncovered the fact that these bond coats transform from B2 to an $L1_0$ martensite during service, e.g. each time the jet engine is started.
- Finite element (FE) models have been constructed and used to show that this transformation plays an important role in determining the reliability and overall life of the TBC system.





As-bond coated



TC- 28% of life

Techniques for microsample (see insert on Abe Lincoln's bowtie) preparation and testing have been developed and used to get the first every mechanical properties measurements of platinum modified nickel aluminide bond coats. A change in mechanical properties associated with thermal cycling was noted, and microstructural investigations evidence the fact that the bond coats change from an ordered intermetallic alloy (B2) to a martensitic phase (L10) each time the engine is thermally cycled. The importance of this transformation on TBC life appears to be significant and has attracted significant attention in the TBC community.

In summary, the major findings, to date, are:

- Bond coat properties (CTE, E, σ_y, $\Delta\sigma_{relax}$) have been measured as a function of T.
- Bond coat properties and microstructure observed to vary with thermal cycling.
- Volume change associated with M to B2 phase change warrants further attention.
- FE models evidence development of residual stresses that depend on the transformation T's.
- Bond coat chemistry plays an important role in governing bond coat transformations.

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Educational Activity:

- 3 undergraduate research assistants: Dan Tobin (03), Mike Taylor (03), David Sparks (04).
- 2 graduate students: Michael Glynn (Ph.D.) and Deng Pan (Ph.D.).
- 1 post-doctoral fellow: Dr. Mingwei Chen (partially supported).

2001 Awards:

- JHU promotion to full professor.
- ASM Materials Science Research Silver Medal

Professional Activity:

- Co-chaired International Symposium on Structural Intermetallics, May 02.
- Vice-chair, Editorial board, *Metall. Mater. Trans.* (01-02).
- 7 invited presentations on GOALI research.
- 7 student presentations on GOALI research.
- 2 visits to GE Aircraft Engines.

Hemker research group Spring 02:

Back: Deng Pan*, Dan Tobin*‡, Mike Taylor*‡, Carolina Elmufdi, Dr. Mingwei Chen*, Haitao Zhang, *Front:* Piyush Jain, Cristian Cionea, Professor Kevin Hemker, Michael Glynn*
Absent: David Sparks* ‡
* worked on this GOALI, ‡ undergraduate